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The following communications were read :—

I. The conclusion of Sir J. Herschel's paper on the Orbits of Binary Stars.

The author states his object in this paper, (which is intended by him as a supplement to his measurements of 364 double stars, lately communicated to this Society,) to be the explanation of a process by which the elliptic elements of the orbits of binary stars may be obtained from such imperfect observations as we possess, both with greater facility, and with higher probability in their favour, than by any system of computation hitherto explained.

The author divides his subject into two parts : first, the general statement of his method of investigation ; and secondly, its application to the cases of some of the most remarkable binary stars known. In the first of these divisions, after enumerating the elements to be determined, and stating in general terms the formulæ of elliptic motion as applicable to the circumstances of the inquiry, he proceeds to consider the points in which the chief difficulty and delicacy of the inquiry itself resides, which he regards as arising not so much from the analytical intricacy of the equations to be resolved, as from the extreme imperfection and conflicting nature of the data afforded by observation. Of these, he considers the measured distances as especially liable to error, and, indeed, so insecure as to render it quite indispensable to discard them altogether from the data employed, and to rely, for the determination of the elements, solely on the observed angles of position and the intervals of time included between the epochs of observation.

It is, therefore, on a consideration of these alone that the processes explained in this paper are grounded. But the observed positions themselves, although much more to be depended on than the distances, are yet liable to errors too considerable to allow of our selecting any given combination of picked observations as data, to the exclusion of others. All the observations we possess must, he remarks, be treated according to one regular process, so as to educe from their assemblage, not several different and mutually-opposing orbits, such as would result from combining them in arbitrary groups, but rather one single resulting orbit, which they shall all agree in supporting, so far as their inherent errors will permit them to agree in supporting any orbit at all.

The processes described in the present communication for accomplishing this object are essentially graphical. They assume the Newtonian law of gravitation and its consequences, the laws of elliptic motion, and may be divided into three separate steps or stages: first, one having for its object the purification of the observations themselves from all that amount of error which can be detected and eliminated by mutual comparison; secondly, the graphical construction of the actual curve into which the orbit of one star about the other, regarded as fixed, appears projected on the visible surface of the heavens, which curve ought to be an ellipse, but not of necessity having the fixed star in its focus; thirdly, from the visible orbit so laid down, the third and last step consists in deducing, by a proper system of combined measurement and computation, the elliptic elements of the true orbit as it exists in space, which must then be compared with all the observations we possess.

The preliminary preparation (or purification from palpable error) of the observations is accomplished by laying down, on a chart of engraved squares, the observed angles of position in the direction of one co-ordinate, while the times of observation are measured off in that of the other. Thus a series of points will be obtained expressive of the *rough* or *observed* angles of position at all the epochs of observation. A curve, called by the author the "interpolating curve," is then prescribed to be drawn, not *through*, but *among* these points, according to certain precepts; and by its aid a series of *rectified* angles of position, corresponding to equal, quinquennial, or decennial intervals of time, is obtained by simple reading off and tabulation. Moreover, tangents being drawn to this curve at its points, which correspond to every fifth or tenth year, the angular velocities (also *rectified* or purified from palpable error) are obtained. Now, these being known, the corresponding apparent distances (which, by the laws of elliptic motion, are inversely as the square roots of the apparent angular velocities,) become also known.

In the course of the statement of this process, the author takes occasion to examine the received processes of interpolation, as applied to such cases, which he considers defective on two distinct grounds: first, that no curve "of a parabolic nature," as usually prescribed, nor *any* other curve than the transcendental one, which expresses the angle of position in terms of the time according to the *true laws* of elliptic motion and the *true data* in the particular case in question, has any claim to preference; and secondly, that even were such a parabolic curve theoretically correct, it would lead to enormous practical errors to subject it to a rigid condition of passing through points liable to such errors as those actually laid down by observation.

The mode of drawing such a curve, in the first instance approximately, and of correcting it afterwards, so as to lead, by an easy and certain process, to its true form, as corresponding with the laws of elliptic motion, are stated at length, partly in the general or introductory part of this paper, and partly in the application of its

principles to the case of a particular double star, 70 *Ophiuchi*, in which the first approximation is insufficient.

When the angles of position and corresponding or *derived* distances are once obtained for intervals sufficiently numerous, it is easy to lay them down on paper, and thus to construct a curve which will express, infinitely better than could have been done by using *observed* positions and *observed* distances, the apparent orbit of the star.

If the points so laid down fall on the circumference of an exact ellipse, all is well; if not, an ellipse must be drawn, not *through*, but *among* them, as well as the case will permit; and *this ellipse* will be the general and single representative of all the data, after passing through these successive processes of rectification and mutual adaptation.

This ellipse existing on paper must be measured, its situation with respect to the meridian, &c. found, and its areas described in known times, either actually cut out and weighed, or an equivalent arithmetical process substituted for the use of the balance; and from such weights and measurements, by the aid of formulæ, which the author states, the true, final, elliptic elements of the real orbit, and its situation in space, are determined.

He then proceeds to apply this mode of operating to the cases of five of the most remarkable binary stars known; viz. *γ Virginis*, *Castor*, *σ Coronæ*, *ξ Ursæ*, and 70 *Ophiuchi*. In those of the first two he is aided by observations by Bradley, made upwards of a century ago, in the nature of allineations with known stars, with which most valuable data he was furnished by the kindness and research of Professor Rigaud. His results tend to indicate (with more or less certainty and precision) an approach of both these double stars to their respective perihelia; the former about the year 1834, the latter about 1855; and in each case he considers it probable that the actual proximity of the two component stars will be extreme, and the apparent angular velocity proportionably rapid, insomuch that in the case of *γ Virginis* an angle of 68° may be described in a single year.

That the degree of credit which may attach to these predictions (if such they can be called) may be fairly estimated, he annexes, in a tabular form, comparisons of his elements with actual observation.

The case of *σ Coronæ* is remarkable only for the precise coincidence of the angles of position, as *rectified* by the process of interpolation used, with a true ellipse; but the star is excessively difficult, and the errors of observation necessarily great. This star is also approaching its true perihelion, which it will attain about 1835.

The case of *ξ Ursæ* leads, by a first approximation, to an orbit so nearly coincident with M. Savary's, (though decidedly inferior to it in its power of representing the earlier observations), that the author considers it unnecessary to go through a second process, which would most probably lead almost precisely to the same conclusions with those of the French geometer.

In the case of 70 *Ophiuchi*, the first orbit arrived at, by means of a curve arbitrarily drawn to interpolate the angles of position, departs too far from an ellipse, and the elements deduced represent the observations too widely to remain satisfied with it. It becomes necessary, therefore, to correct the work, or execute a second approximation; which done, an orbit is deduced representing, within the limits of error of good observations, the whole series of angles of position which have been obtained by micrometric measurement. The author remarks, as a singular fact, that the elements so obtained differ materially from those of Professor Encke for the same star, especially in the period, in which the discrepancy amounts to six years, while yet the two orbits represent the observations equally well throughout nearly five-eighths of the whole ellipse.

Since the distances are not at all considered in this process, the major axis must be determined by comparing the radii vectores of the ellipse deduced, in parts of an arbitrary scale, with observation, so as to convert such parts into seconds of visible distance. This comparison, properly conducted, by comparing the sum of all the observed distances with that of all the measured radii, will give a co-efficient of reduction whence the axis can be easily had. When obtained, the theoretical distances can be computed without farther reference to observation, and thus become a check (so far as the observations can be depended on) on all the foregoing work. In the case of γ *Virginis*, the measured distances have diminished, since the earliest observations we possess, from between 6″ and 7″ to less than 2″. This diminution, which has been regularly progressive, is faithfully represented by the computed radii; so that a very considerable corroboration is thus afforded both to the actual orbit arrived at, and to the probability of a yet much nearer appulse, in which the stars will be seen separated in none but the finest telescopes.

The periods of the five double stars whose elements are here computed are as follow:—

γ Virginis	513 years.
σ Coronæ.....	287
Castor	253
70 Ophiuchi	80
ξ Ursæ.....	58

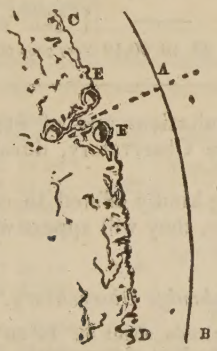
The author concludes this paper by stating, that he has received great assistance in the pretty extensive numerical computations into which the subject has led him, from the contrivance and use of a piece of mechanism, by which the solution of the equation between the mean and eccentric anomalies in the theory of elliptic motion,

$$u - e \cdot \sin u = nt.$$

is obtained by mere inspection and reading off, and that the principle of this mechanism is applicable to other and more complicated cases.

II. Account of the Occultation of 119 and 120 *Tauri* by the Moon, on December 18th, 1831. By Sir James South. In a Letter to Mr. Baily.

"The night of Sunday, December 18th, was remarkably fine, the air clear, and the stars unusually steady. The barometer stood at 29·35 inches, and the thermometer (attached to the transit circle) 45°,0. At about $0^h\ 45^m$ the five-feet equatorial, armed with a power of 133, was directed to 119 *Tauri*. The star was exquisitely defined, and very steady. The moon was within 10 hours of the full: her dark limb was of course invisible; but, by carrying the eye along the apparent upper limb towards the apparent lower (both of which were illuminated), the situation of the unillumined border might be determined without much chance of error, and the moment the star reached the presumed limb, which it did at $0^h\ 57^m\ 15^s,75$, it instantaneously disappeared, and a more satisfactory observation I never made. At about $1^h\ 15^m$ I returned to the instrument, and found 120 *Tauri* fast approached by the moon, the star remarkably steady, and the moon unusually so. The same eye-piece was used as at the occultation of the previous star; nor was its adjustment in the *slightest* manner varied. On the moon's presumed unillumined border touching it, its splendour remained unimpaired; and having traversed the generally unillumined portion of the disc, presented itself midway between two illuminated mountains, commanding, as it were, the entrance to an unilluminated bay, as represented in the accompanying diagram: it moved majestically along, bisecting by its course the angle of the bay, till, inosculating with an illuminated ridge forming the angular termination of the bay, it became invisible at $1^h\ 27^m\ 5^s,86$."

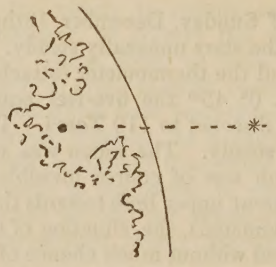


AB the unillumined limb.
CD the rough illuminated edge.
E and F illuminated mountains at the entrance of the *un*illuminated bay.
The dotted line represents the star's course. Its disappearance was at the angular point.

The same phenomenon was observed by Sir James South's assistant, and also by Mr. Richardson and Mr. Simms, at Greenwich. There will be an occultation of the same stars on the 9th of March, at $10^h\ 13^m$ and $10^h\ 49^m$ sidereal time, or $11^h\ 2^m$ and $11^h\ 38^m$ mean time.

Since the above was written, Sir James South has received the following sketch of the appearance of the path of the same star, as observed by Mr. Simms, at the Royal Observatory of Greenwich. The star disappeared at the black dot, and must have passed the

dark limb of the moon at least 40 seconds. The telescope used was a dumpy reflector, by Cuthbert.



III. Observation of Occultations of Stars by the Moon, made at Bedford, by Captain Smyth, between the months of January and December, 1831. Those made in the month of December are subjoined.

Date.	Star, &c.	Immersion.	Emersion.	Remarks.
1831.		h m s	h m s	
Dec. 7	♅'s 1st satel.	———	0 16 30,55	Seen through driving clouds in the S.W. Wind also S.W.
17	γ Tauri.	21 17 ?	22 08 ?	Most unfavourably seen through clouds, and only inserted to shew the probable state of the prediction.
—	99 Tauri.	———	2 40 ?	
18	119 Tauri.	0 57 17,00	1 54 14,95	Both well seen. Immersion between two protuberances.
—	120 Tauri.	1 26 41,99	2 28 30,25	Imm. very good, but hazy at emersion.
22	A small star.	13 36 26,10	———	Barely perceptible in the lunar light.
—	α Leonis.	13 40 27,12	———	Excellent. Projected 1¼″ on the bright limb. Emersion lost.
23	♅'s 1st satel.	———	23 40 00,10	Very good observation.

IV. Observations of Occultations and of Stars observed with the Moon, at the Cambridge Observatory, during the year 1831. By Professor Airy.

*** Professor Airy having kindly offered to communicate these observations monthly in future, they will appear with those made at Greenwich.

Occultations observed at Cambridge Observatory, in the year 1831.

Astronomical latitude, about 52° 12′ 50″.
Longitude, 23^{s},54 East of Greenwich.

Jan. 26. Disappearance of *f* Gemin. at the dark limb.

	h	m	s		
Airy	6	38	30,60	Cambridge sidereal time.	Good obs.
Rothman ...	6	38	30,50		

June 1. Disappearance of Jupiter at the bright limb.

1st limb of Jupiter.	h	m	s	2nd limb of Jupiter.	h	m	s
Airy.....	17	46	41,87	Airy.....	17	48	22,65
Rothman.....	17	46	46,85	Rothman.....	17	48	21,85
Whewell.....	17	46	42,51	Whewell.....	17	48	15,77

Reappearance of Jupiter at the dark limb.

1st limb of Jupiter.	h m s	2nd limb of Jupiter.	h m s
Airy.....	18 53 35,62 (good)	Airy.....	18 55 19,20
Rothman	18 53 35,87	Rothman... .	18 55 20,87
Whewell	18 53 36,85	Whewell.....	18 55 18,35

Oct. 21. Disappearance of ξ^2 Ceti at bright limb 22 35 33,11
Reappearance of ξ^2 Ceti at dark limb ..... 23 28 53,84 } Airy.

Pretty good.

23. Disappearance of θ^1 Tauri, at bright limb 23 36 47,45
Disappearance of θ^2 Tauri 23 47 16,05

		h m s
Oct. 23.	Disappearance of 75 Tauri	23 54 3,08
	Reappearance of θ^2 Tauri, at dark limb	0 14 14,86
	Reappearance of 75 Tauri	0 26 1,15
	Disappearance of Aldebaran	3 6 52,49
	Reappearance of Aldebaran.....	4 13 32,40

All good: those of Aldebaran excellent. Deep projection at the immersion.

		h m s
Nov. 26.	Reappearance of Saturn at the dark limb. First appearance of light	10 3 46,46
Dec. 17.	Reappearance of γ Tauri, at the bright limb...	22 11 41,54
	Disappearance of Aldebaran at the dark limb...	4 45 10,50

The observation of Aldebaran very good.

22. Disappearance of Regulus at the bright limb.

	h m s
Airy	13 42 55,06 (very good)
Whewell	13 42 53,66 +
Another observer	13 42 55,08

All the observers saw the star hang on the limb, and in some degree projected on the disc. Mr. Whewell considered the time to be a large fraction of a second later than that set down.

Transits of the Moon and Moon-culminating Stars, observed at Cambridge Observatory, in the year 1831.

Date.	Name.	Clock Time of Transit. h m s	Clock's losing rate s
Jan. 25.	Moon 1 L.	6 25 12,12	
	G Gemin.	6 38 47,78	−0,27
	(281) Gem.	6 46 34,01	
	ζ Gemin.	6 52 46,73	
26.	Moon 1 L.	7 27 45,12	−0,28
	3 Cancri	7 49 47,92	
Feb. 22.	Moon 1 L.	7 4 5,46	−0,06
	f Gemin.	7 28 21,54	
	3 Cancri	7 49 44,79	
26.	48 Leonis	10 24 38,63	−0,26
	o^1 Sextant.	10 35 57,37	
	Moon 2 L.	10 52 36,54	
Mar. 23.	Moon 1 L.	8 42 56,32	+0,56
	π^2 Cancri	9 4 22,02	
	(74) Leonis	9 14 38,71	
	7 Leonis	9 25 6,59	
Mar. 27.	(77) Leon.	11 17 44,80	+0,22
	υ Leonis	11 26 47,02	
	Moon 1 L.	12 11 0,21	
Apr. 20.	Moon 1 L.	9 21 48,10	+0,44
	ψ Leonis	9 32 47,11	
21.	Moon 1 L.	10 15 1,06	+0,44
	ϱ Leonis	10 22 9,89	
May 25.	o^2 Libræ	15 11 32,62	+0,68
	γ Libræ	15 24 0,67	
	Moon 1 L.	15 38 12,54	
June 20.	$\varkappa$ Virginis	14 1 34,54	+0,48
	Moon 1 L.	14 34 3,57	
	ξ^2 Libræ	14 45 17,92	
21.	o^1 Libræ	15 9 16,21	+0,52
	Moon 1 L.	15 22 4,02	

Date.	Name.	Clock Time of Transit. h m s	Clock's losing rate s
June 21.	η Libræ	15 32 15,53	+0,52
	θ Libræ	15 41 53,91	
22.	Moon 1 L.	16 11 14,37	+0,65
	φ Ophiuchi	16 19 8,92	
July 3.	Moon 2 L.	1 51 7,86	+0,57
	α Ceti	2 50 59,77	
24.	Moon 1 L.	20 14 28,55	
	Moon 2 L.	20 16 40,48	+0,44
	υ Capric.	20 27 48,64	
	(310) Capr.	20 37 8,28	
	19 Capr.	20 42 37,85	
25.	(240) Capr.	20 28 25,22	+0,63
	(386) Capr.	20 45 35,44	
	θ Capr.	20 53 49,33	
	Moon 2 L.	21 10 6,88	
Aug. 23.	(46) Aquar.	22 5 3,81	+0,35
	σ Aquarii	22 18 48,96	
	Moon 2 L.	22 36 31,47	
Sept. 22.	(33) Pisc.	0 6 6,55	+0,10
	t Piscium	0 13 44,17	
	(120) Pisc.	0 23 52,00	
	Moon 2 L.	0 55 41,38	
Oct. 17.	(142) Aqu.	22 22 4,31	−0,11
	64 Aquar.	22 27 14,33	
	Moon 1 L.	22 38 53,30	
	χ^3 Aquar.	23 7 2,29	
19.	(227) Pisc.	23 42 59,04	+0,38
	(270) Pisc.	23 53 15,54	
	10 Ceti	0 14 49,01	
	Moon 1 L.	0 26 53,98	
21.	(144) Pisc.	1 28 32,58	+0,20
	o Piscium	1 33 19,88	
Oct. 21.	ξ^2 Ceti	2 0 54,37	+0,20
	Moon 2 L.	2 23 2,61	
28.	Moon 2 L.	9 34 11,11	−0,22
	α Leonis	9 56 12,75	
Nov. 13.	40 Aquar.	22 1 19,38	0,00
	Moon 1 L.	22 15 8,36	
	70 Aquar.	22 36 32,04	
	K Aquar.	22 41 30,27	
15.	n Piscium	23 36 11,93	−0,36
	24 Piscium	23 41 11,28	
	Moon 1 L.	23 59 39,02	
16.	(33) Pisc.	0 6 4,12	−0,36
	t Piscium	0 13 41,88	
	Moon 1 L.	0 53 46,34	
	(57) Ceti	1 10 52,65	
19.	Moon 2 L.	3 54 6,00	−0,59
	48 Tauri	4 3 10,82	
	γ Tauri	4 7 10,77	
	ϖ Tauri	4 14 3,58	
28.	β Virginis	11 38 49,97	−0,24
	η Virginis	12 8 11,91	
	Moon 2 L.	12 45 10,43	
Dec. 10.	Moon 1 L.	21 56 15,73	+0,29
	D Aquarii	22 6 52,11	
	50 Aquarii	22 12 19,45	
	f Aquarii	22 18 9,75	
14.	(189) Pisc.	0 36 26,95	+0,09
	e Piscium	0 56 35,91	
	Moon 1 L.	1 22 2,33	
15.	ξ^1 Ceti	2 0 59,26	0,00
	Moon 1 L.	2 17 57,06	

The longitude of Cambridge Observatory is $23^s,54$ east of Greenwich.
(A positive rate is losing, and a negative rate gaining.)

V. Stars observed with the Moon, at Greenwich, in December 1831. From the Astronomer Royal.

		h m s	Daily Rate of the Clock.
December 10.	Moon 1 L.	22 0 9,88	+1″,0
	50 Aquarii	22 16 12,86	
12.	Moon 1 L.	23 41 15,68	+1 ,1
	249 Piscium.....	23 51 52,68	
18.	l^2 Tauri	4 59 18,80	+1 ,7
	(43) Tauri	5 10 46,96	
	(115) Tauri	5 17 45,23	
	Moon 1 L.	5 30 11,48	
	Clock regulated during the interval.		
19.	χ^3 Orionis	5 54 18,26	−0 ,05 Cloudy.
	ν Geminorum . .	6 19 20,92	
	Moon 2 L.	6 40 35,25	

Mr. Baily announced from the chair that he had received a communication from Professor Schumacher, stating that His Majesty the King of Denmark, who enters with a lively and personal interest into every subject connected with the promotion of science, had founded a gold medal, of the value of twenty ducats, to be given to the first discoverer of a comet, not of known revolution, nor visible to the naked eye, subject to the following conditions; viz.

1. The medal is to be given to any person who may first discover a telescopic comet (that is, not visible to the naked eye,) and not of known revolution. If any doubt should arise as to what class it belongs, the decision is to be left to Professor Schumacher.

2. The discoverer must send notice to Professor Schumacher by the first post after the discovery, and fix the time of the discovery as well as he can, in order to enable Professor Schumacher to decide between several discoverers, and fix the absolute time of the first discovery, with regard to the longitude of the place, when the comet shall have been seen by more than one person on the same night.

3. This notice must contain the best possible determination of the position of the comet, and the direction of its course, if this can be ascertained from the observations of one night.

4. If the first night's observations are not sufficient to determine the direction of its course, the discoverer must, as soon as he gets a second observation, communicate it to Professor Schumacher.

5. Professor Schumacher is to decide whether a discovery is to be considered as established or not.

6. The medal is to be adjudged six months after the discovery.

7. All astronomers out of Europe may therefore enter into competition for the medal, if the above-mentioned notice come to the hands of Professor Schumacher within six months after the discovery; but, after that time, no claim can be allowed, nor any medal given.

J. Moyes, 28, Castle Street, Leicester Square.